Meeting on August 20th 2002

Minutes taker Ina Reichel

Those present J. Corlett, M. Placidi, I. Reichel, A. Wolski, W. Wan, A. Zholents

Date August 26 2002

Distribution
J. Corlett
M. Placidi
I. Reichel
D. Robin
S. de Santis
W. Wan
A. Wolski
A. Zholents

Overview of topics

1 Relaxing R_{56} in the first compressor (A. Zholents)

After last weeks discussion, Sasha looked at the longitudinal phase space for different scenarios of changing R_{56} and the correlated energy spread in the first compressor (see also the attached note at page 34ff):

- $R_{56} = 0.72\,\mathrm{m}$: This is the "old" number. It uses a correlated energy spread of ± 20 keV and a bunch length of ± 10 ps. The second compressor in this case uses $R_{56} = 0.93\,\mathrm{m}$.
- $R_{56} = 0.18\,\mathrm{m}$: With the linearizer at 1.4 MeV and a phase angle of $-15°$ from the crest (angle was optimized) one still gets the desired bunch length of ± 5 ps but keeps a correlated energy spread which is distorted after passing the pre-linac.With the second linearizer at 12 MeV and a phase angle of $-10°$ one then

uses $R_{56} = 0.55\,\mathrm{m}$ in the second compressor (see Fig. 22). With this, the final bunch looks very similar to the "old" design. The bunch is slightly shorter but has a slightly larger energy spread. Both compressors also need a non-zero R_{566}.

- $R_{56} = 0\,\mathrm{m}$ with dogleg: As the second compressor contains an arc bending $180°$, it is fairly easy to achieve a large R_{56}. Therefore Sasha also looked at doing away with the first compressor and doing all the compression from 20 ps to 2 ps in the second compressor. This would also eliminate the first linearizer. The second (and now only) linearizer needs to run at 13.5 MeV and $-3°$. In the second compressor an R_{56} of 1.86 m but no R_{566} is needed. The results on the final bunch length and energy spread are comparable to the other scenarios. This option has the advantage of having potentially less problems with coherent synchrotron radiation and space charge as the bunch length is only shortened at an energy of 120 MeV instead of at 10 MeV.

  In order to use this solution one needs a very large R_{56} in the second compressor. Sasha rematched the lattice with the larger R_{56} and found a solution. The β-functions are not that different from the "old" version but the dispersion is significantly larger in the arc (see Fig. 22).

  In this case the dogleg part is fairly simple. Sasha has a basic lattice which is not yet matched to the boundary conditions (see Fig. 23).

- $R_{56} = 0\,\mathrm{m}$ without dogleg: As it is not clear if we really will ever use energy recovery, in case of doing away with the first compressor one could also think about doing away with the dogleg, too, as its sole reason for being is now energy recovery. This might allow putting the flat beam adaptor in between the linearizer and the arc instead of before the pre-linac, i.e. do the flat beam conversion at a higher energy which might solve some of the space charge problems.

For all cases of smaller (or zero) R_{56} the transverse effects need to be studied. Andy had a short look at it but found out that MERLIN does not take the energy spread into account correctly. He is working on fixing that and hopes to have first results by next week.

2 Update on a design of the first bunch compressor (W. Wan)

Weishi now has a solution with reasonable β-functions (see Fig. 24). R_{56} is tunable over a large range.

3 TraFiC4 (I. Reichel)

Ina put the compressor part of the first compressor beamline in (but not the rest of the beamline yet). So far it seems to work.

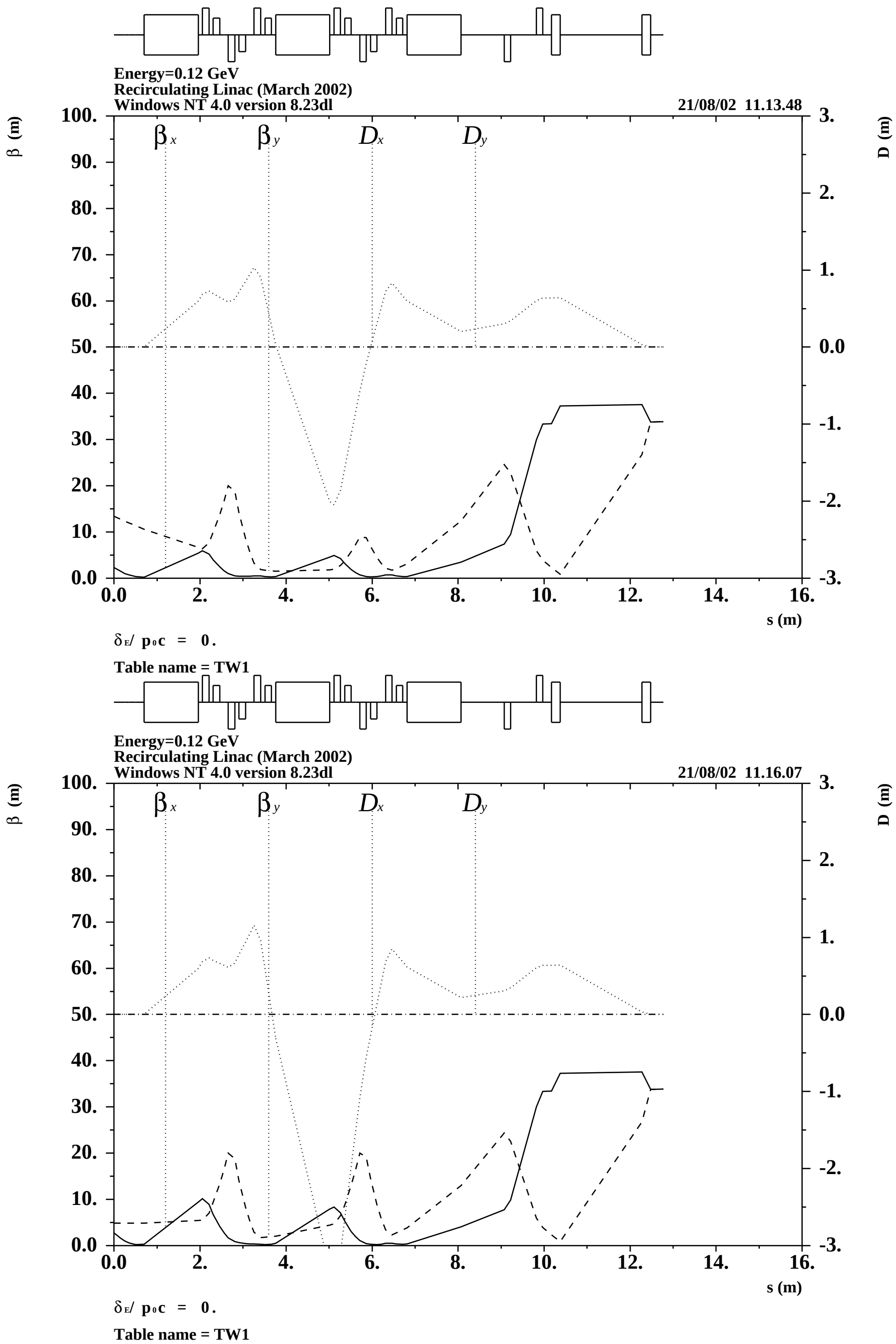

Figure 22: Lattice for the second compressor with $R_{56} = 0.55\,\mathrm{m}$ (top) and R_{56} =1.86 m (bottom).

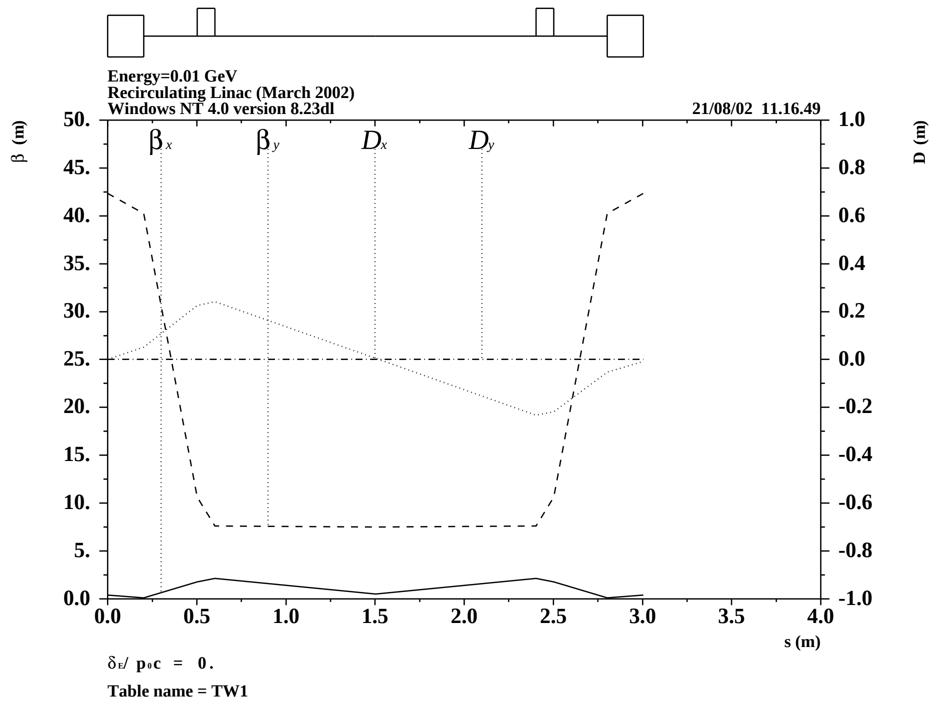

Figure 23: Dogleg used instead of the first compressor (not yet matched to the boundary conditions).

As it is not clear what is going to happen with the first compressor, Ina will instead now put the second compressor in TraFiC4 and work on a MAD to TraFiC4 converter. Sasha suggested using the output of the `tape` command in MAD as input for the converter.

4 Lattice database and CVS (I. Reichel)

So far still no one has tried the test-files in CVS. Weishi will give Ina an up-to-date version of the lattice files to put in CVS.

5 Tracking through photon production section

Massimo suggested we soon track the photon production section to study effects of offsets in quadrupoles (vertical dispersion) or phase errors of the crab cavity. In order to do that with MERLIN Andy needs the map for the crab cavity. Weishi said that he thinks it is included in Etienne's code. He will look it up and give some information to Andy so that it can be included in MERLIN. John suggested to start with an ideal kick and see what happens.

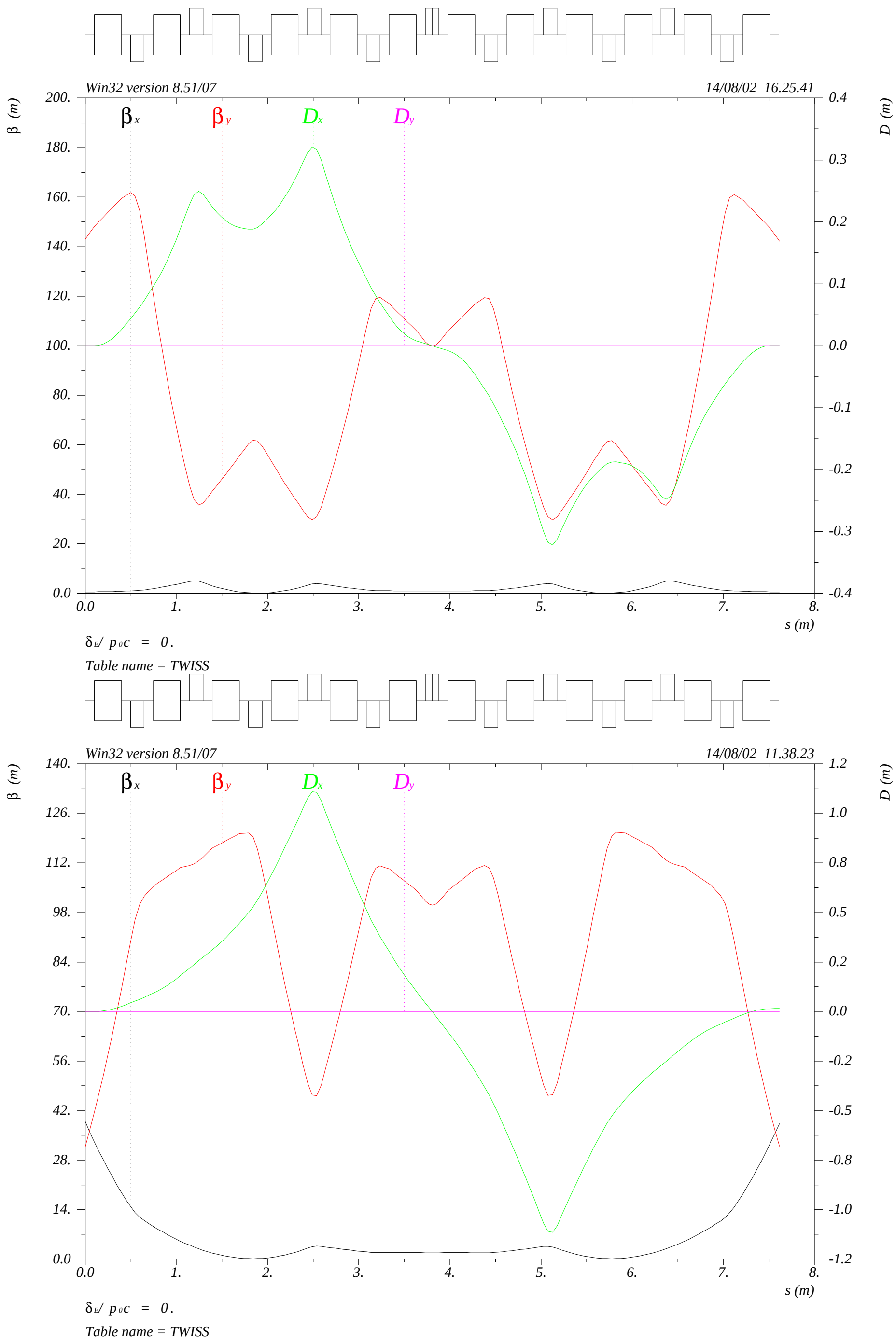

Figure 24: Lattice for the first compressor without dedicated compressor for $R_{56} = -0.26\,\mathrm{m}$ (top) and $R_{56} = -0.80\,\mathrm{m}$ (bottom).

6 Note on longitudinal dynamics with reduced R_{56}

CBP Tech. Note
August 14, 2002

Longitudinal Dynamics in the Femtosource for a Case of Reduced R56 Values

Andy Wolski and Alexander Zholents

This note describes a continuation of a study of the longitudinal dynamics in the Femtosource originated in [1].

In the original scheme we used two bunch compressors with R56 values of 0.73 m for the first bunch compressor and 0.93 m for the second bunch compressor. Attempts to produce a practical design for the first bunch compressor had demonstrated that it could be much simplier if R56 was several times smaller.

Therefore, we consider two new schemes.

In the first scheme we increased the correlated energy modulation in the first linearizer and reduced R56 in the first bunch compressor. Details of the longitudinal dynamics for this case are shown in figures 1 through 9. It is necessary to point out that in the new scheme the electron bunch propagates through the injector linac with head to tail correlated energy spread of approximately ± 130 keV.

In the second scheme we completely eliminate the first bunch compressor and do all compression from 20 ps to 2 ps in the second bunch compressor at 120 MeV. All details for this schee beginning from the end of the injector linac are shown in figures 11 through 15.

■ The first scheme

In the following plots below we show the evolution of the longitudinal phase space of the electron bunch as it progresses down the chain of the accelerators and bunch compressors. We considered only the case of a 20 ps electron bunch emerging from the photocathode gun. We begin with the window-frame distribution shown in Figure 1, where border lines are set at ± 10 ps and ± 20 keV. This is assumed to be the border lines for our longitudinal emittance coming out of the photocathode gun.

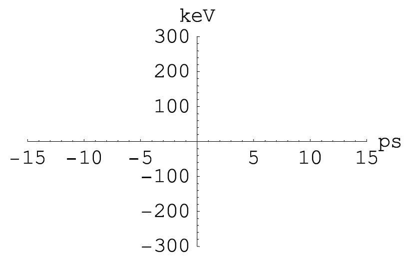

Figure 1. The initial launch of the particles.

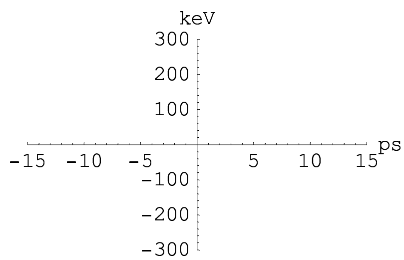

Figure 2. At the exit of the photocathode gun after acceleration to 10 MeV at the crest of the RF waveform (0° phase).

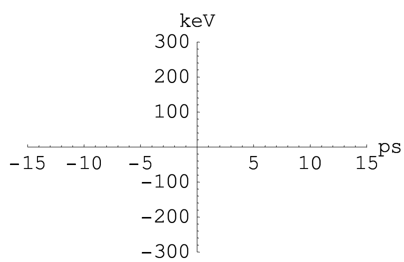

Figure 3. After the first linearizer: frequency=3.9 GHz, peak voltage=-1.4 MV, RF phase= -15°.

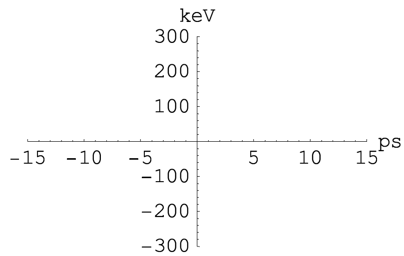

Figure 4. After the first bunch compressor. Time-of-flight matrix coefficients are: R56=0.18 m, T566=-2 m.

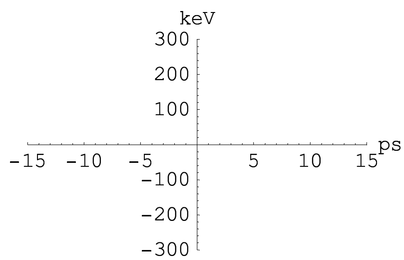

Figure 5. After the acceleration in the injector linac: peak voltage=110 MV, RF phase= -1°.

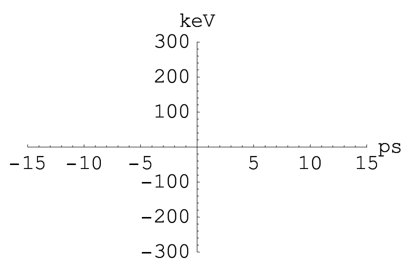

Figure 6. After the second linearizer: frequency=3.9 GHz, peak voltage=-12 MV, RF phase= -10°.

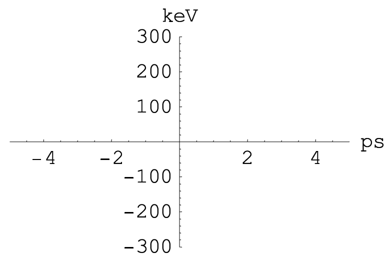

Figure 7. After the second bunch compression in the injection arc. Time-of-flight matrix coefficients are: R56=0.55 m, T566=-2 m.

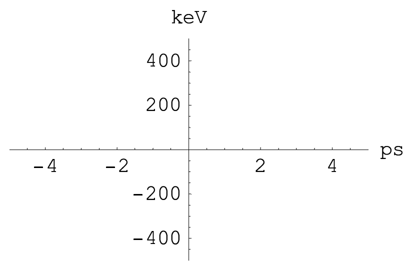

Figure 8. After the acceleration to 2.5 GeV in the reciculating linac at the crest of the RF waveform for the first three passes and at -0.4° phase at the last pass.

Next we pass the electron beam through the RF deflection cavity operated at 3.9 GHz at 90° phase from the crest. The following plot shows the tilt angle obtained by the electrons in the undulator as a function of the longitudinal off-set.

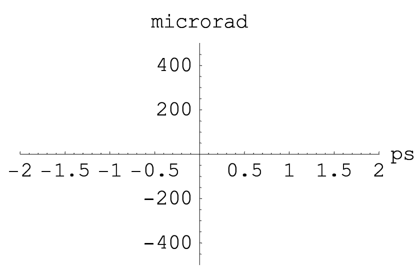

Figure 9. After the RF deflection: 3.9 GHz, 90° phase.

For comparison we show in Figure 10 the longitudinal phase space as it was in the original scheme at the end of the acceleration.

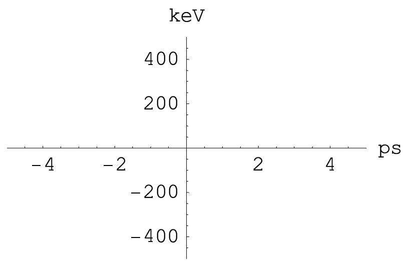

Figure 10. After the acceleration to 2.5 GeV in the reciculating linac. The original case described in [1].

■ The second scheme

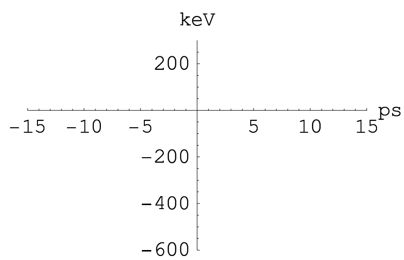

Figure 11. After the acceleration in the injector linac: peak voltage=110 MV, RF phase= 0°.

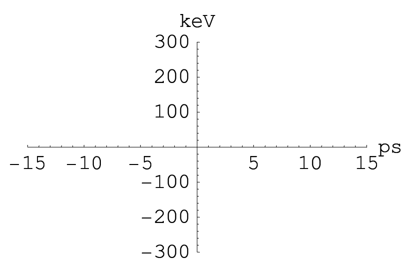

Figure 12. After the second linearizer: frequency=3.9 GHz, peak voltage=-13.5 MV, RF phase= -3°.

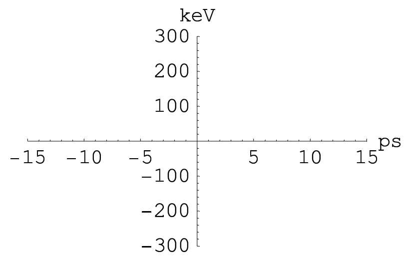

Figure 13. After the second bunch compression in the injection arc. Time-of-flight matrix coefficients are: R56=1.86 m, T566=0 m.

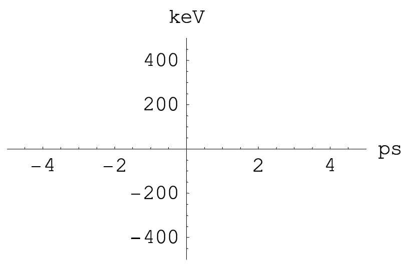

Figure 14. After the acceleration to 2.5 GeV in the reciculating linac at the crest of the RF waveform for the first three passes and at -0.1° phase at the last pass.

Next we pass the electron beam through the RF deflection cavity operated at 3.9 GHz at 90° phase from the crest. The following plot shows the tilt angle obtained by the electrons in the undulator as a function of the longitudinal off-set.

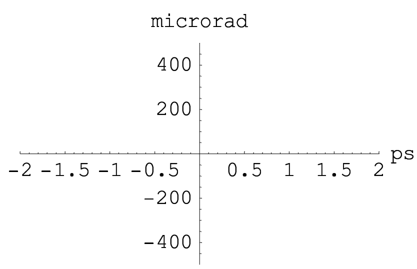

Figure 15. After the RF deflection: 3.9 GHz, 90° phase.

■ Transverse dynamics

As the next step we studied the effect of the RF focusing on the electron beam in the injector linac with correlated head to tail energy variation.

■ References

1. A. Zholents, "Longitudinal Dynamics of Electrons in the Femtosource Without Beam Current Effects", CBP Tech. Note 243, March 7, 2002.